



Proposal for an Air Pollution Alert System for the South Coast Air Basin

by Kenneth Heitner

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Preface

The Environmental Quality Laboratory has disseminated the results of its work in a series of detailed formal reports that are widely circulated. In many cases, however, it is more important that the information be disseminated quickly but to a smaller group. To facilitate the circulation of this second kind of information a different form of report, which we will term an EQL Memorandum, has been established. The recipients for each note will be selected on an ad hoc basis but the notes will be available to anyone on request.



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ABOUT THE AUTHOR

Dr. Kenneth L. Heitner is Research Engineer at the Environmental Quality Laboratory, California Institute of Technology. Originally trained at the Webb Institute of Naval Architecture, he came to Caltech in 1964 as a graduate student in Applied Mechanics studying tsunami waves as part of the Earthquake Engineering Laboratory program. He received his Ph.D. in 1969 and continued as a Research Fellow at the Institute.

He spent six months with the Naval Undersea Research and Development Center, but returned to Caltech in January 1971 to join the new Environmental Quality Laboratory. At EQL, his main activities have been in air pollution abatement strategies and problems involved in novel methods of siting power plants.

PROPOSAL FOR AN AIR POLLUTION ALERT SYSTEM

FOR THE SOUTH COAST AIR BASIN

by

Kenneth Heitner*

The purpose of this proposal is to provide a meaningful alert plan for the South Coast Air Basin that could also be useful in other basins. The key element of the proposal is the calling of a significant number (10-20 per year) of alerts on the days when air pollution levels are predicted to be most severe. During these alerts, definite and enforceable restrictions on use of motor vehicles would be in effect to sharply reduce and/or eliminate pollution from this source. In addition, alert conditions would restrict certain types of industrial and commercial activity. Finally, better health warning information would be provided to allow the most sensitive fraction of the population to avoid exposure to conditions they cannot tolerate.

We begin the discussion by defining measures of pollution severity based on both the average level and exposure time as a basis for deciding on what measures should be taken. The specific control measures are suggested based on the current distribution of the emissions from various sources. They would limit the emissions of the sources with the highest emission factors first, but progressively tighten the control as the severity of the pollution increases.

A procedure for predicting when alerts will occur is described. This procedure will minimize the disruption involved in calling an alert by taking

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advantage of the natural diurnal cycle of human activities in the basin. It also recognizes that there is a time lag in the build-up of secondary pollutants (oxidant and NO_2) and that emissions of primary pollutants (hydrocarbons and NO_x) must be restricted before the atmospheric reaction takes place.

Finally, we give estimates of how often different levels of alert would typically be called, based on the suggested levels. The use of alerts as an incentive to adopt low emissions technology and/or adopt activities that reduce the per capita pollution, such as car pooling, will also be discussed.

I. Definition of Episode Criteria

Several different sets of ambient air quality criteria have been defined both by the EPA and the ARB, as well as the Los Angeles County Medical Association.

They are as follows:

1. EPA's "never to be reached" ambient air quality levels.¹
2. EPA's ambient air quality standards.²
3. ARB's ambient air quality standards.²
4. EPA's air pollution episode criteria.³
5. ARB's air pollution episode criteria.⁴
6. Los Angeles County Medical Association (LACMA) Health Warning Recommendation.⁵

In trying to organize all of these criteria to find a logical basis for the alert levels, the various criteria were plotted as points on graph having pollutant concentration as the vertical axis and exposure time as the horizontal axis. Log scales were used so that data could be examined over a wide range of concentration and exposure time.

Figure I is such a plot for oxidant, with Figures II and III for CO and NO₂ respectively. The criteria indicates that a given level of pollution severity is both a function of the average concentration and the exposure time. Higher

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1. Federal Register, October 23, 1971, p. 20513
 2. ARB Bulletin, May-June, 1971 p.3
 3. Federal Register, November 25, 1971, p. 22414
 4. Draft of ARB proposed emergency plan, August 10, 1972.
 5. Letter from J. Takamine, President of LACMA to Robert Chass, LAAPCD, dated July 2, 1971.

Figure 1 Suggested Alert Conditions for Oxidant

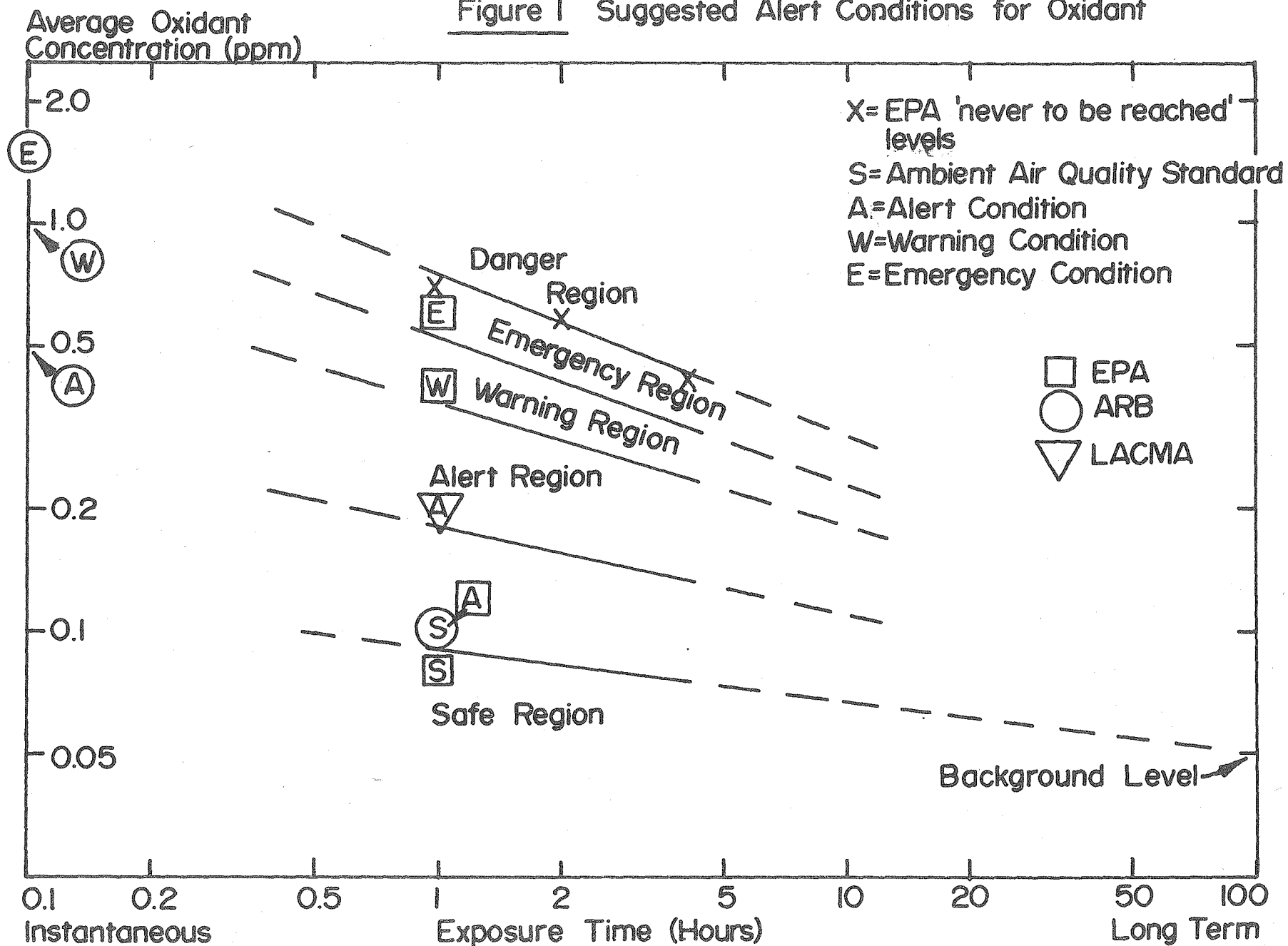


Figure II Suggested Alert Conditions for CO

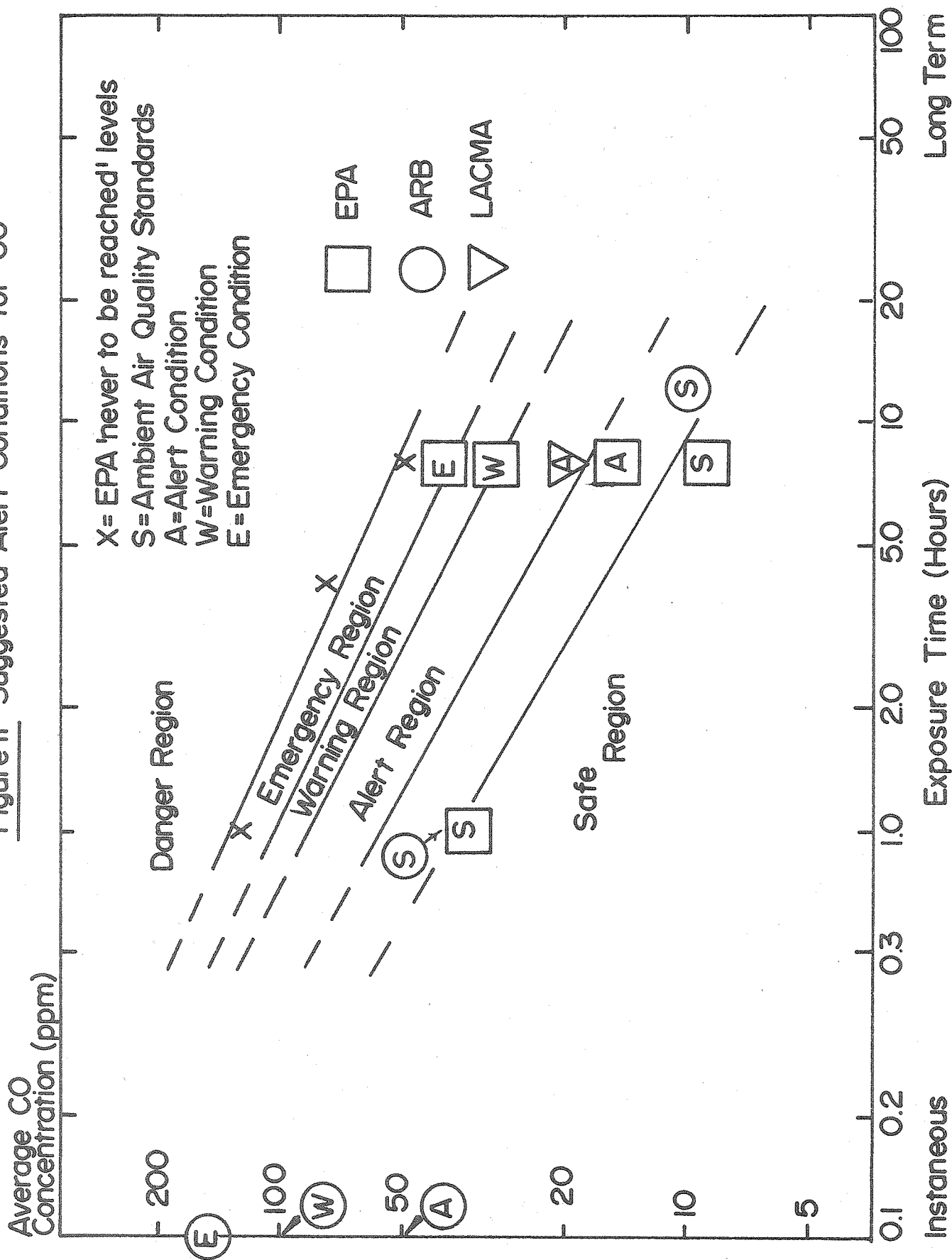
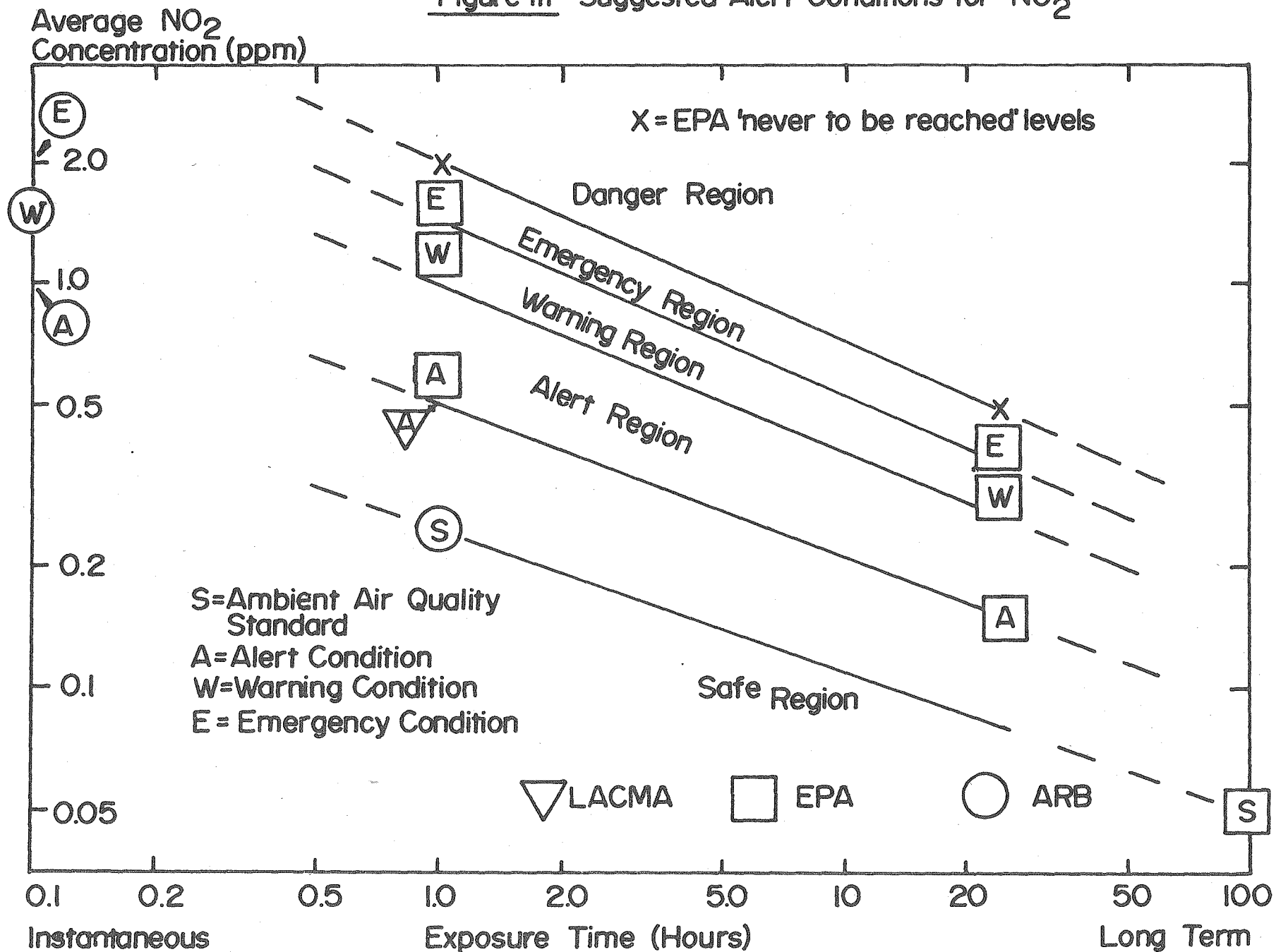


Figure III Suggested Alert Conditions for NO₂



levels of pollution are permissible for short periods of time, but long term averages must be lower. This fact is reflected in the EPA's "never to be reached" levels, as well as the ARB and EPA ambient air quality standards for NO₂ and CO. For oxidant, there is only a single point standard, so the background level was used as a basis to define an additional "point" standard.

It was felt that this observation provided the basis to use a simple mathematical model, of the form

$$\left(\begin{array}{c} \text{Pollution} \\ \text{Severity} \end{array} \right) = \left(\begin{array}{c} \text{Average} \\ \text{Concentration} \end{array} \right)^a \times \left(\begin{array}{c} \text{Exposure} \\ \text{Time} \end{array} \right)^b$$

where a and b are constants used to fit the criteria. These curves come out as straight lines on the log-log scale, simplifying the presentation.

Thus as shown in Figure I, II, and III the EPA's "never to be reached" levels can be joined by a line defining the lower boundary of a "Danger region." The ambient air quality standards define an upper boundary to a "Safe region." In between lies a zone where the severity worsens as one progresses from the "Safe region" to the "Danger region."

It should be noted that these regions are defined on the basis of health effects. The "Danger region" is defined as "levels which could cause significant harm to the health of persons," the "Safe region" as "levels of air quality, necessary, with an adequate margin of safety, to protect the public health."

In choosing further subdivisions, we have also used health criteria. The Los Angeles County Medical Association recommended levels* for Health Alerts to persons "at increased risk because of coronary artery disease or chronic

* We interpret the LACMA recommendation of 1.0 ppm oxides of nitrogen total for one hour as 0.5 ppm NO₂ for one hour. This decision reflects the average make-up of the oxides of nitrogen, though the ratios vary from 20% to 80% NO₂ depending on location and season.

respiratory diseases." Estimates on the "at risk" population vary from 200,000 to 700,000 persons in the South Coast Air Basin. These health standards are the basis for defining the "Alert region."

At higher levels, two additional regions, Warning and Emergency, have been defined to provide safety margins against ever reaching the "Danger region." The Warning level is also selected to provide a reasonable number of days when people will be inconvenienced by the Warning level regulations so as to adopt changes that reduce pollution.

The levels we have suggested in general correspond with the EPA's suggested episode criteria, although our Alert levels for oxidant and CO are higher, and our Warning and Emergency levels are slightly lower. These values are also in general agreement with those proposed by the ARB's recently appointed Ad-Hoc Medical Advisory Committee.* The committee has suggested slightly lower numbers for short term CO exposures, perhaps because this would imply a lower long term average.

This is in contrast to the earlier proposal for instantaneous levels made by the ARB and shown on Figures I-III. For example, in the oxidant case (Figure I), the proposed instantaneous Alert level of 0.50 ppm has been reached only 4-5 days per year on the average. However, the level of 0.20 ppm for 1 hour has been violated roughly 80-100 days per year. A lower instantaneous Alert level, about 0.25-0.30 ppm would correlate better with the 0.20 ppm for 1 hour.

It is to avoid these difficulties, that we prefer the continuous definition of the Alert, Warning, and Emergency levels over different averaging times. This procedure becomes even more important for CO and NO₂, where the definitions of the various regions extend to longer exposure times and the high instantaneous thresholds may never be crossed, although the long term average has become significant in terms of pollution severity.

*Draft of Ad-Hoc Medical Advisory Committee to ARB dated November 8, 1972

II. Measures to be Taken at Each Level

The control measures proposed for each level serve two main purposes. One is that they provide significant reductions in emissions of primary pollutants by restricting and/or eliminating polluting activities. Secondly, they provide incentives to reduce pollution through permanent changes, which eventually reduces the need to call alerts.

At present we suggest the following measures for each level:

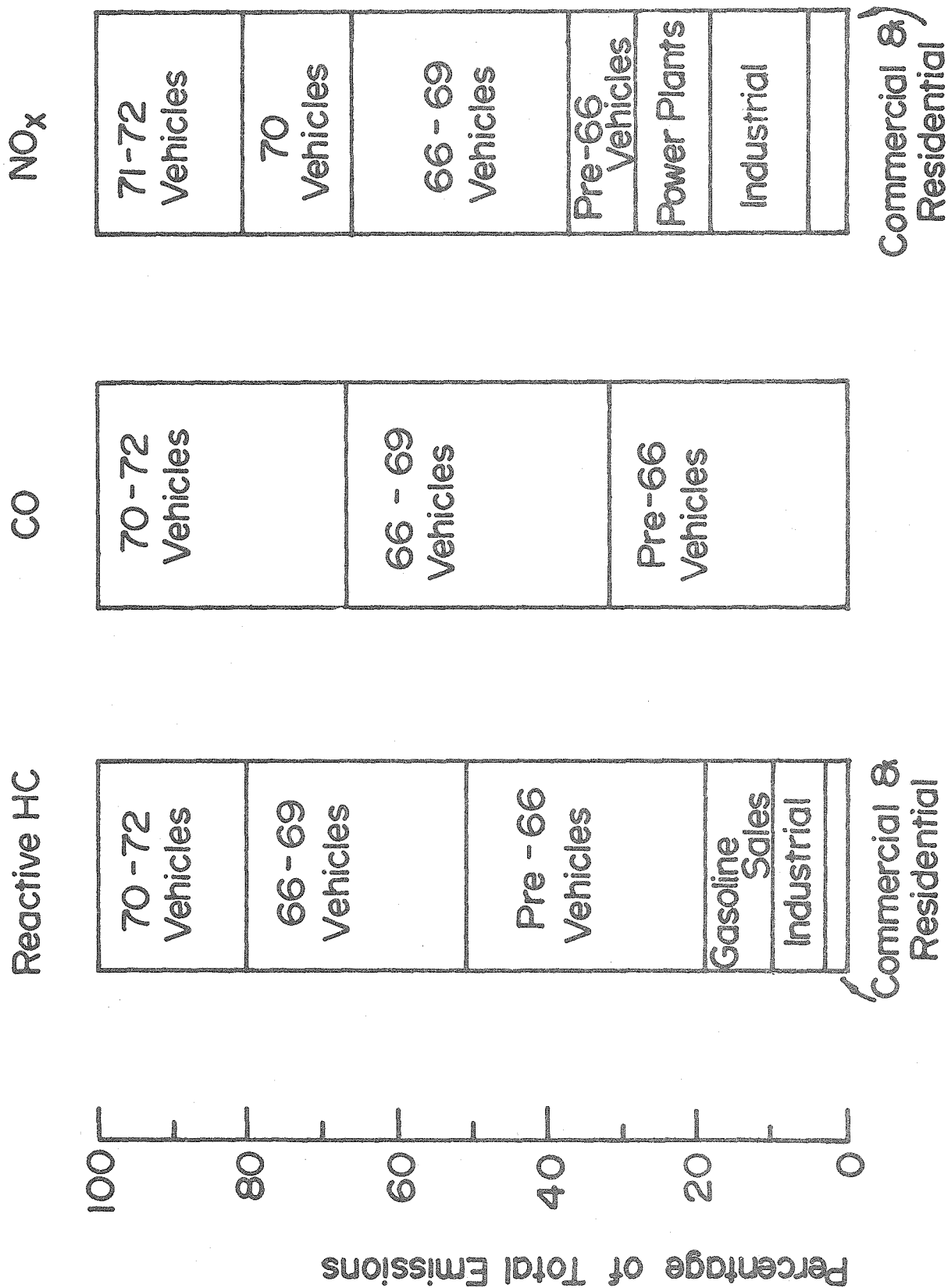
Alert -- This is primarily a health warning level, especially for that fraction of the population with respiratory problems. These people are most likely aware of their difficulty; what they need is information to enable them to plan their activities so they can avoid periods of high pollution.

This procedure is already being followed with the Los Angeles APCD's School and Health Warning Information. The current levels used for predicting these warnings are instantaneous values of 0.35 ppm for ozone, 40 ppm for carbon monoxide and 1.5 ppm for nitrogen oxides.* With the lower Alert Condition values we have suggested, this could serve as a beginning of a Health Alert Program. Also, it would be desirable to see that such information is given considerably more attention in the news media than it receives at present.

Warning -- The goal for the warning condition is to reduce emissions by approximately one half of normal. Figure IV gives an approximate breakdown of the emissions sources based on Los Angeles county for 1972 (It must be remembered that the South Coast Air Basin numbers will be slightly different and the numbers will change every year. Thus the measures will also have to be continually reviewed and modified.)

* APCD Digest, January 1972, p.3

Figure IV Distribution of Emissions by Major Sources for 1972
Los Angeles County



To achieve the required emissions reductions it is obvious that the largest source, motor vehicles, must be controlled first. A large fraction of these emissions come from the older vehicles and so nominally their operation would be "restricted" first. This action would provide an incentive to purchase newer vehicles, or to convert vehicles to operate on gaseous fuels.*

A procedure for restricting the operation of automobiles at the Warning level follows: The restricted vehicles would carry one color sticker and a zone number. The zones would be 2-3 miles on a side and nominally constructed to include access to shopping, schools etc., if possible. Restricted class vehicle owners have to organize car pool arrangements with at least one or perhaps two other restricted class vehicle owners. For their two or three vehicles only one sticker and zone number is issued. Thus only one of the two or three vehicles may operate at any time during the Warning alert. Unlimited use of this common vehicle in the local zone is allowed. This is a "neighborhood" car pool. Car pools for long trips out of the zone, i.e., to and from work etc., may also be organized. However, operation outside the vehicle's local zone requires the vehicle carry two or three people in addition to the appropriate sticker.

Unrestricted (newer low emission or gaseous fueled vehicles) would be exempt from these restrictions and would be identified by a separate colored sticker. The remaining vehicles could not be operated in a Warning Alert.

Each year the newest vehicles would enter the unrestricted category and some of the older vehicles would be placed in the restricted class.

On the basis of the emissions data for 1972, it is suggested that for oxidant Warning levels, the operation of pre-1970 vehicles be "restricted".

* "SMOG: A Report to the People of the South Coast Air Basin," EQL, California Institute of Technology, Pasadena, California, January 1971, p. 13.

In addition consideration should be given to restricting the use of highly reactive solvents in both the industrial and commercial sector, as well as restrictions on gasoline sales and deliveries to stations that do not have complete vapor recovery systems.

For CO Warning levels, restriction of pre-1970 vehicles would be required.

For NO₂ Warning levels, restriction of pre-1971 cars would be desirable. However, to try to simplify the administration of the alerts, a compromise at restricting the pre-1970 vehicles is adequate. Again, consideration of restricting sources in the industrial and commercial sectors should be made. Sources that have active NOx reduction systems would be excepted.

Other procedures for drastically reducing emissions could be envisioned that would simplify administration of Warning alerts, such as an outright ban on the operation of older vehicles. The suggested procedure attempts to mitigate the 'side effects' of such a strict measure.

Emergency -- At this level, a complete cessation of normal activities is required to avoid the "Danger region." The EPA has detailed a typical outline of a complete set of restrictions.* These restrictions should be explicit and as complete as possible. Although it is expected such conditions in this basin would not persist for long periods, consideration as to how a prolonged Emergency would be handled seems important. At this point, the authorities should have guidelines in order to decide what types of operations can be allowed to supply essentials such as food, medical care, etc. to the population

* Federal Register, November 25, 1971, p. 22416.

III. Procedure for Calling Alerts

Alerts should be called on the basis of predicted air pollution levels rather than actual occurrence of the specified conditions. This procedure allows people to plan their activities in advance, rather than catching them unprepared when the alert is called. The practice of predicting alerts also avoids formation of high levels of secondary pollutants (oxidant and NO_2) by preventing the emissions of primary pollutants under conditions that would favor the photochemical reactions.

The Los Angeles APCD has been forecasting ozone levels for several years.* The forecasting is excellent 75% of the time and poor only 8% of the time. It is less accurate for inland areas. However, it operates under the handicap of having to predict the following day's pollutant levels by 10:00 AM in the morning, before the present day's actual levels are known. This requirement can be dropped and the forecast for the following day be made available to the public via radio and television in the evening. An expanded observational network would also improve forecast quality. At present, the District is forecasting maximum of ozone, carbon monoxide and nitrogen oxides as the basis for School and Health Smog Warnings. The forecasting procedures will have to be modified to correspond with the requirements to predict conditions involving time averaged levels. They also will have to be expanded to cover all areas in the South Coast Air Basin.

Finally, our observations of the APCD data for the worst smog months indicate that the days with high summertime oxidant levels and high wintertime CO occur in "strings" of several days in a row. (See Tables I and II) If the first day of a string was missed by the prediction procedure, the high levels of oxidant

* Forecasting Ozone Maxima for Los Angeles County, Arthur Wachtenheim and Ralph W. Keith, APCD Paper No. 69-78.

TABLE I

SUMMERTIME PEAK OXIDANT LEVELS FOR

AZUSA (STATION 60) JULY 1972








DAY	Peak Oxidant (ppm)	DAY	Peak Oxidant	DAY	Peak Oxidant
1	.26	11	.49 ↑	21	NO DATA
2	.26	12	.38 ↓	22	.24
3	.32 ↑	13	.51 ↓	23	.26
4	.33	14	NO DATA	24	.31 ↑
5	.34	15	.18	25	.32
6	.30	16	.20	26	.31 ↓
7	.30 ↓	17	.12	27	.19
8	.14	18	.17	28	.46
9	.20	19	.12	29	.23
10	.27	20	.07	30	.33 ↑
				31	.31

↑
String of days over 0.30 ppm maximum oxidant
↓

TABLE II

WINTERTIME PEAK CARBON MONOXIDE LEVELS FOR

EL SEGUNDO (STATION 76) DECEMBER 1971

DAY	Peak CO (ppm)	DAY	Peak CO	DAY	Peak CO
1	33	11	31	21	25
2	25	12	25	22	15
3	18	13	18	23	28
4	26	14	27	24	11
5	31 	15	21	25	4
6	34 	16	33 	26	14
7	17	17	46 	27	16
8	28	18	40 	28	23
9	35	19	16	29	22
10	26	20	29	30	37 
				31	49 

 String of days over 30 ppm maximum CO.

or CO experienced would provide a basis for calling alerts on the succeeding days, assuming the meteorology is expected to be the same.

IV. Number of Alerts, Warnings and Emergencies Expected

Table III is an estimate of the frequency of alerts based on the criteria we have recommended. If higher levels of contaminant concentration are used the frequency of the various alert levels decreases. We feel that the regulations suggested for the Warning level will cause considerable confusion when the first Warnings are instituted. It would seem desirable to place compliance with the regulations on a voluntary basis for the first few episodes, until people learned to cope with this new problem. After a certain date, the regulations would be enforced with fines and other penalties to ensure compliance. Some of the regulations may be found to be untenable and the procedures for the episode could be modified during this time.

Emergency episodes are rather infrequent occurrences and may not need any trial runs. Compliance with the Emergency regulations may also benefit from the experiences gained in the first Warning episodes.

As the average emissions levels continue to drop because of the increasing percentage of stringently controlled vehicles and stationary sources, the number of alerts will decrease. Depending upon what seems desirable when we achieve such lower levels, either the alert levels can be lowered, to further reduce pollution "peaks" and continue to provide a "clean up" incentive, or they can be allowed to "fade away" by maintaining them at these levels as the air quality improves.

TABLE III

ESTIMATED FREQUENCY OF ALERT LEVELS FOR 1972

(Days/Year)

Oxidant	Alert 60	Warning 5-10	Emergency 1-2
CO	60	5-10	RARE
NO ₂	10	1-2	RARE